

II. *Part of some Letters from Mr Anthony van Leeuwenhoek, F. R. S. to the Royal Society, and the Right Honourable the Lord Somers their President, containing several Microscopical Observations and Experiments concerning the Animalcula in Semine Masculino of Cocks and Spiders, Shortness of Breath, &c.*

Delf, Decemb. 1701.

I Take the Liberty of sending your Lordship some little Figures and Observations which I made partly the last year, and partly this.

In my Letter of the 25th of *Decemb.* 1700. I told the Society that I had made some Remarks on the *Semen Masculinum* of a young Cock that was but half grown, and that I should consider it farther before I gave you my Thoughts upon that subject.

I have often observed, that young Cocks that are not arrived to half their Growth were wont to Tease the young Hens to couple with them, which these last always refused till they had laid Eggs, that is to say, till they were 3 or 4 months old.

This made me conclude that when the young Cocks were thus stimulated to Copulation, the *Animalcula* in their Seed were living, which upon view I always found to be so, as did many others to whom I imparted the strange sight of infinite numbers of these Living Creatures; and the last person that view'd them through my Microscopes was of opinion that he saw Millions of those little Creatures, tho the whole Drop of Seed in which they lay was to the Naked Eye no bigger than a great, but fine Sand.

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Last

Last Summer I open'd the Seminal Vessels of a young Cock that was newly kill'd, pluckt, and still warm; in which I likewise discover'd these *Animalcula* still living; and they remain'd alive for the space of half an hour after I had squeez'd a Drop of the Seed out of the said Vessels.

I was formerly of opinion, that the *Animalcula in Semine Masculino* of a Cock (as they then appear'd to me, both swimming in their Fluid Matter, as also after they were Dead) were in Shape like our River-Eels, but by my late Observations I find I was mistaken in my Thoughts; for now they appear, both in motion and when they lye still, as if the fore-part of their Body were crooked or Circular.

Not content with my own Observations, I took a great deal of pains to give the Limner a Distinct View of them; which happen'd very well, and is as follows.

Tab. 1. Fig. 1. A B C D Represents one of those little Creatures in its whole length, whereof A B C is the Body, which is seldom quite straight, but the Tail mostly folded; and that was the occasion of my error; for when I view'd them formerly, I thought I had seen their whole Body, whereas I now discover'd a long and exceeding small Tail, which is shown by C D.

These Tails were so wonderful fine, that I had much ado to make the Limner perceive them, for by reason of their smallness, they often escape the sharpest sight.

In the fore-part of the Bodies of many of those *Animalcula* I discover'd a clear bright place, which was not to be seen in others; and the Tails of all these little Creatures that lay dead were so many Bows, which I caus'd the Limner to describe in Tab. 1. Fig. 2. 3. 4. and 5.

From hence, I suppose, it is, that when I mentioned the *Animalcula in Semine Masculino* of other Creatures, I took no notice of their long Tails, which without doubt they were provided with, as well as these in the Seed of young Cocks.

On the 17th of *Septemb.* 1701. about 10 of the Clock in the morning, I view'd again the *Semen Masculinum* of a young Cock, which the Poulterer judg'd to be about twelve weeks old, it had been kill'd an hour before, and found the *Animalcula* full of Life.

I took some of the same Seed, about the quantity of a great Pin's head, and so order'd it, that very little of the fluid Matter could exhale.

I observ'd this Matter every hour, and in the same evening about seven of the Clock I found the *Animalcula* as lively as if they were proceeding from a Cock that was newly kill'd.

But about 8 or 9 a clock I could perceive that many of the *Animalcula* were dead, and that in one place, the space whereof was no larger than a Sand, there were great shoals of them living; but a little further, and in a place of much the same extent, I could not discover the least Motion in those that lay there.

The 18th of *September* in the morning, about seven a clock, and also at noon about twelve, I again made my Observations of the same Seed, as it lay in a Glass Tube, of the largeness of a thick Pin, but I could see no life in the *Animalcula*; but when I lookt upon another part of the same Matter, of the bigness of a great Sand, and spread very thin upon the Glass, I saw a great many very lively and nimble in their Motion, but their Life and Motion dwindled away till at last I could perceive none; the reason of which I judg'd to be, that the thin fluid Matter was all exhale'd from the Seed, and that then the *Animalcula* dye presently.

To satisfy my self farther in this matter, I took a dead Cock that had been kill'd and pluckt the day before, between the hours of seven and nine in the morning, and opening the Body, I pull'd out the Guts and the Stomach, that I might the better come at the *Vasa Seminalia Deferentia*, I squeez'd out of one of the Seminal Vessels a Drop of

the Seed, and presently setting it before my Microscope, I could see an infinite number of those *Animalcula*, swimming in Legions together, and crossing one another like Clouds in a stormy day, and as Brisk and Lively as if the Cock had been newly kill'd.

That part of the Intrails which I had taken out of the Cock, I put into the Body again, and drew the Skin over it, in order to take out a little more of the Seed about six hours after.

At noon accordingly I took out a little of the Seed, and found the *Animalcula* in the same still living.

But in the evening about six having again taken some of the *Semen* out of the *Vasa Deferentia*, I could not perceive any of them living.

Then I open'd those Vessels in several places, even where they terminate in the Testicles, but the *Animalcula* were all dead.

Seeing now the *Animalcula* in *Semine Masculino* are living when taken out of the Body of the Cock, warmth so long after the Cock itself is dead, who knows but as the same are placed for to fasten in the *Ovarium* or Egg-nest of the Hen, not one Yolk, but many, which compose the Bed of Eggs, and so to impregnate them; the more because we find, that with one Coition of the Cock and the Hen, most of the Eggs which the Hen lays in a month or two, are impregnated.

I have often thought too, whether or no the Yolks of the Eggs being in the *Ovarium*, and not having attain'd the hundredth part of their Growth, are not made for each of them to receive one of those *Animalcula* from the Seed of the Cock, and to keep it there till the Yolk of the Egg be furrounded by the White, and the necessary Heat introduced; the more, because we know that out of the White of the Egg the Chicken receives its first Growth.

Delft in Holland, Decemb. 20. 1701.

With the present I send you my farther Observations about Spiders, upon which subject there occur'd to me what follows.

A certain Gentleman, that had often consider'd the nature of Spiders, and their Copulation, told me that one could seldom meet with the Males of the great Spiders, and that he believed the Females did kill and eat up the Males.

This Gentleman had order'd his Gardener to kill no Spiders.

This Gentlemans Garden was large, and full of low Fruit-Trees, so that the great numbers of Spiders in those Trees were very visible to us; and I was told by the same Gentleman, that where we saw the Females of the smaller sort of Spiders, there was also one Male; and I have observed the same.

Now that which this Gentleman took for the *Membrum Virile*, was quite otherwise, and I told him he was mistaken; for the more I view'd them the more I was convinc'd that they were two Working Instruments, where-with the Spiders take up their Food, and use also instead of short Feet.

This my Assertion seem'd to the Gentleman Incredible; but when I placed the Working Instruments before my Microscopes, and gave him a Prospect of them he was fully satisfied; adding, that they could not be the *Membrum Virile*, and that unless he had seen them thro the Microscopes, he should never have believed them to be otherwise.

Moreover, since that time I have often been in places where Thistles, Nettles and other Weeds grew, where I saw several sorts of Spiders, and in great numbers; and observ'd that when the Male Spiders approacht the Females.

males, in order, as I thought, to couple, the Females always put the Males to flight.

I have several times taken up the Male Spiders, that I might observe their Seed, and have been fully satisfied that that little white Matter which I squeeze'd several times out of the hinder part of their Bodies, and which was sometimes as large as one grain of Sand, and sometimes a little bigger, was nothing else but the Male Seed of these Creatures; I discover'd therein an infinite number of *Animalcula*, which continued so long living, till I was wearied with beholding them.

These *Animalcula* were so exceeding small, that I believe a thousand millions of their Bodies joyn'd together would not be equal to a large grain of Sand, yet I will rather compare them (that I may be sure not to be mistaken) to a Barley Corn for bigness.

By reason of the infinite smallness of these Creatures, it was impossible for me to represent the Figure of their Bodies, nor of the Instruments thereof wherewith they moved so strongly, as to continue living above 5 hours after they were separated from the Bodies of the Spiders.

I had 10 or 12 other Male Spiders, in which I could discover no new *Phænomena*, so that I took it for granted that the *Membrum Virile* of these Creatures is in the hinder part of the Body, tho I never was so lucky as to observe an actual Copulation.

'Tis true, that in all the last Spiders I could perceive no Seed at all; but that I attributed to these reasons, either the Male Seed was not yet Ripe enough in them, or it may be they had lately coupled before I took 'em. It has sometimes happened to me, that in the pressing their Seed out, I mixed their Excrements with it.

Since these Experiments I shut up several Spiders in a Glass Tube, and amongst others 3 Males and 1 Female together, and after the space of 2 days, I saw the Female fall upon the Males with such violence, that the Blood

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ran out of their Feet ; whereupon I kill'd the Female, and the next day I saw two of the Male Spiders lying dead, and the remaining Male Spider was eagerly devouring the Female.

I had three other Male Spiders that I had shut up in the Glas Tube twice 24 hours, and so having hinder'd them all that time from coupling with their Females, I concluded I should find seed enough in all of them, and so indeed it happened, and I observ'd the *Animalcula* alive in it.

Delft in Holland, Febr. 14. 1702.

I Have been mightily perswaded by several Gentlemen to send you the following Observations, together with the inclos'd Figures, if perhaps they may be of use to such as are troubled with *Shortness of Breath*.

Some time before the King went for *England*, I had frequent Discourse with a certain Physician about the Curing of Shortness of Breath ; who told me, that he was well acquainted with all the sorts of Balsam that were esteem'd useful in that Disease, but that it was impossible to find any Vehicle that could insinuate them effectually into the Lungs, and that in vain do they anoint the Breast and Stomach with Balsams that could never reach the Lungs, and that the Scent of the Balsam which exhaled from those that us'd to anoint their Breast with Oyl, does not exhale from the Pipes of the Lungs, but was evaporated from the Breast by the Neck.

I was also perswaded of the Truth of this Assertion, because I am convinced that nothing that is in the Stomach or Bowels can be convey'd to the Lungs, unless it has first pass'd thro the Heart ; and consequently much less can Balsams,

fams wherewith we anoint our Breasts, find any Passage into the Lungs.

Having consider'd this Discourse some days by my self, and upon the sixth of *January* last finding a very Learned Gentleman at my house, we fell into talk of *Shortness of Breath*; and I told him that the only means I could think of, to insinuate the Invisible Particles of Balsam into the Lungs, was to take a little piece of Silver or Copper, of the bigness of a Shilling, and making a small hole in it, to fill the Cavity with a little Balsam proper for the Lungs of one that is troubled with a *Shortness of Breath*, and when that is done, let him place it upon the Tongue, and stopping his Nostrils, let him admit no Air into his Lungs but thro his Mouth, nor Respire thro his Nostrils, by which means the Subtil Particles of the Balsam, which I'll call the Spirits of it, may exhale and descend into the Pipes of the Lungs.

This Project of mine was approved of by the aforesaid Gentleman; who added, that he did not doubt but I should still improve it if I thought farther upon that matter.

After the Departure of the said Gentleman, I took two Glass Tubes, one of nine Inches, and t'other of eighteen long, and of half an Inch Diameter.

I made several Bends in these Glass Tubes, and made a small Hole at the end of each of them, fit for my purpose, and in order to put it into one's Mouth, and filling it half full of Balsam, I placed it horizontally, that the Air passing over the Balsam might be convey'd into the Lungs, more strongly tinged with the said Balsam than it could be by the other Project.

But taking Counsel of my Pillow, I rejected this way also, and the next morning I took a Glass Tube, that was 15 Inches long and about one Inch in Diameter, as is design'd by Tab. 2. Fig. 1. A B C D E, &c.

That

That end which is put into the Mouth, in order to draw in the Air, is represented by DEF.

This Glass Tube being open at A I K is to be fill'd with a piece of Linnen, which we call Gawse or Muslin, or else a little bit of Spunge, of such a size that it might be put into the Tube without pressing, and that a Thread or String might be fastned to it, in order to pull the Spunge or Linnen out of the Tube, as is to be seen in K L, and this Rag or Spunge is to be moisten'd in Balsam good for the Lungs, before it is put into the Tube. See B C G H.

But considering, that if the said Spunge did not touch the sides of the Glass in every part, the Air would pass by it, where there was no resistance, as also that the Air would difficultly pass thro the Linnen or Spunge that was dipt in Balsam, especially if that were thick, I rejected this Tube also, and took another of the same length and breadth with the former, save only that this last Tube was very near of the same size throughout.

I rejected this Tube also after all my preparations, and I took another Tube of the same length and bigness with the former, with this difference only, that it was throughout of the same size.

This Tube, which is represented by Tab. 2. Fig 2. M N O P, &c. I stop't at each end with a Cork as at M N W X and P Q S T.

In the uppermost Cork P Q S T, I made a little round Hole quite thro, wherein I strongly insinuated a small Glass Tube R, and so also I perforated the other Cork M N W X.

Having done this, I thrust into the lowermost Cork another long Crooked Glass Tube which I had prepared on purpose, and it is describ'd by the Letters Y Z.

This last Tube Y Z was taper'd into a slender end as Z z, with the intent, that the Air when suckt in at R should come in leisurely at the strait passage Z A.

Having thus disposed the great Tube, with the Cork so strongly skrew'd in it, and the small Tube in the Cork, that

not only no Water, but even no Air could enter therein, I judged that I had quite finish'd my Machine.

To make an Experiment how it might succeed, I drew the Cork PQST out of the Tube, and pour'd a little Brandy into it as in NOVW, and then having placed the said Cork with the little Tube in it, into the great Tube again, and putting the small Tube R between my Lips, and sucking in the Air, which rush'd in at the small end a of the Tube YZ, and which was obliged to pass thro the Brandy, I perceiv'd the Brandy to be put into a violent agitation and bubbling, and thereby the Spirits thereof, if I may so call them, made to rise in an extraordinary manner up into the Mouth, and consequently into the Lungs, as the Event did plainly demonstrate.

If then the Exhalations or Volatile Particles of Balsams are render'd serviceable, not only for the comforting, but even for the curing of Weak and Crazy Lungs, and the more Spirits of these Balsams can be convey'd into the Lungs, the better will they fare, but I would not have the Air pass so simply thro the Balsam, as it went thro the Brandy, when the Tube should be filled with the former so far as it was with the latter, but intended to put the Glass Tube, so far as it is filled with Balsam in hot Water; however, in order to prevent the bursting of the Tube by too sudden a Heat, it ought to be laid in a Basin fit for the purpose, with some cold Water, pouring softly a little boiling Water upon it to the height of the Balsam, or else to lay the Tube in a Basin with the necessary quantity of Water, and put it upon Fire.

By this means the Spirits of the Balsams will exhale much more freely than if the Balsams were cold, and the Lungs will be so heated thereby (in my opinion) as to put the Patient into a gentle Sweat.

I have often thought with my self too, that these Balsams, or at least some Cordial Gums, Herbs or Juices, are not only good against Shortness of Breath, but also
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will preserve the Lungs from cold stinking Mist, and Pesti-
lential Airs.

I have been told, that the best Balsam for Shortness of
Breath is the Balsam of *Peru*, which I never saw, neither
did I intend to make the above-mentioned Instrument a Ve-
hicle for Balsams, for I freely own, I have no skill of Bal-
sams of Gums or Herbs, only this I have often experi-
enced, that stinking smells are prejudicial to my Lungs.

I don't design to invite any body to make use of the said
Tube, besides I have presented it to an able Physician, who
is well vers'd in those Balsams, Gums, and Juices, that are
good for the Lungs.

That Learned Person, that I mention'd before, setting
the Tube to his Mouth, and breathing in the Spirits of the
Brandy, I told him that we need not stop our Nose when
we draw in our Breath, but only remove the Tube, Tab. 2.
Fig. 1. DEF from the Mouth, and then Breathing, to apply
the Tube again to the Mouth ; and this one is to repeat so
long as one shall find any benefit by it ; this Gentleman, I
say, was so pleas'd with the Experiment, that he advis'd
me to make it Publick, that the World might be the better
for it.

Now in order to make the Glass Tube, Fig 1. as useful
as the other, Fig. 2. I prepared such another Instrument as is
represented by Tab. 2. Fig. 3. ABCDEF, that I might place
the Cork ABCD in Tab. 2. Fig. 1. at AI ; and I made this
Instrument or slender Glass Tube longer than that which in
Fig. 2. is represented by YZ, upon this account, *viz.* that
if one were inclin'd to put more Balsams or Juices into the
Tube, this long Pipe might be thrust up higher into the
Water.

Now if we consider the Structure of our Bodies, as far
as they are known to us, we may firmly conclude that no
part of us is expos'd to so many Evils as the Lungs, for
how easily may they be hurt if we do but go into the Cold
Air, which engenders and causes us to discharge Phlegm,

to Cough and Spit, for how easily may the Globules of Blood in the fine Vessels of the Lungs be coagulated by the Cold.

In order to get a further Light into these matters, I took the smallest of the Lungs of two several Sheep, that I might view those parts with the Microscope, and I was amazed to discover that the Air Vessels were filled with *Pus* or Matter, even at the extremity or smallest part of the Lungs.

I got a Butcher, that was a good understanding man, to come and view the said Lungs, and I ask'd him what was the Distemper of that Sheep ; he felt the Lungs in several places, and shew'd me some hard parts about the length and breadth of two Fingers, and told me that that Sheep had caught cold, and that had occasioned that Disease of his Lungs ; and the same thing was attested by several other Butchers ; I askt them whither the Sheep would not have died of that Disease, but was answered, that those hard places often *disappear* and remove again.

I could not discover the least *Pus* or Matter in the Air Vessels of the Lungs of two other Sheep, those Lungs were of an agreeable Colour, and like the other.

Having view'd the outside of the Lungs of a Sheep that had not been distemper'd, it seem'd to me that a great many small Transparent Globules lay under the Membrane ; but when I separated the Membrane from the Liver, those Transparent Globules appeared to be nothing else but small Particles of Air prest together into different and irregular Figures ; and those Air Globules seem to lye out of the Air Vessels.

I took several pieces of the Lungs, and prest the Blood out of the Vessels in which it lay, as also their Air, and was amazed at the infinite number of Bubbles of Air that came out of the Vessels, of which some of them were so exceeding small, that they even escaped the sight of my Microscopes ; those Globules I did suppose to be contained
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in very fine Vessels, and when the Blood and the Air was squeez'd out of that part of the Lungs, where there were no great Vessels, the remaining ones, whose Tunics were exceeding fine, made together but a very small Portion of Matter.

Moreover, I took the unsound Lungs of two other Sheep, and found in the handling that their parts were much harder than others that were not distemper'd, and that the Matter or *Pus* was stiffer or thicker in those Lungs, than in the above-mention'd: looking on the external parts of these Lungs, I perceived in several places thereof Pellucid Particles, which far exceeded in largeness the Globules of Air spoken of before.

These clear Particles were in some places of a greyish colour, but in others something darker.

Having taken the last mentioned Particles out of the Lungs, they seem'd to be nothing but a hard Matter, and the more, because upon parting them I could see no Air Globules among them; whereas in sound Lungs, how small soever the pieces thereof were, I could easily discover that (except the Veins) they consisted mostly of Air Globules, which were not shut up within the Veins.

Now if the said Transparent Particles were not in sound Lungs, I should conclude that all those Particles would turn to a thin Matter, in order to be cast out of the Lungs by the Sheep if it should recover its former health.

If we look upon sound Lungs, we should be apt to affirm that those also consisted of such Transparent Particles, but upon a nearer view, I found that that Phenomenon was only occasioned by a multitude of Blood Vessels lying within the Membrane of the Lungs, and in several places seeming to divide the Globules of Air.

Being perswaded now that all the Distempers in the Lungs of Sheep are occasion'd by the Cold Air which these Beasts suck in, I ask'd two Butchers whence they thought the Diseases of their Lungs to proceed, they answer'd, that the

the Sheeps running in the Meadows at the latter end of the Autumn, and eating Grass that was either actually frozen, or cover'd with cold Dews, was the true reason their Lungs were thus spoil'd ; and that the same happen'd sometimes in *May*.

But for my part, I should rather conclude that the frozen Grass does not hurt their Lungs, but Stomachs, and that the cold Air does not affect their Lungs.

Knowing that our Butchers fetch abundance of Fat Sheep from *Brabant*, and that those Sheep are driven every morning into the Field, and folded every night by their Shepherds ; and that our Sheep, on the contrary, are brought into the Meadows in *May*, and there left till it Snows and Freezes ; I askt the Butcher whether the *Brabant* Sheep had such bad Lungs as ours ; and was answer'd, Seldom or never.

From whence I was still better satisfied, that the Diseases in the Lungs of Sheep, and especially of such as lye in the Field in the long cold Nights, were occasion'd by nothing else but their sucking in the Cold Air.

I askt moreover whether such Sheep were Fat whilst they were kept up, and whether they could distinguish while living which had bad Lungs ; to which they answer'd, that those whose Lungs were toucht, did never increase in fat after they were stall'd ; and that within a fortnights time after they had been shut up, and fed with Beans in order to fatning, the Distemper usually disclosed it self, for they did nothing but Cough, and therefore they always kill'd those Sheep first.

Now if we allow that the Cold Air is so prejudicial to the Lungs, we ought not to wonder if such an Inconvenience (as we call a Cold) comes upon them, tho we are able to discover from whence it proceeds.

Yea, I am of opinion, that in a long cold Winter the Lungs may be so much incommoded, that a great fit of
Sick-

Sickness, and even Death itself, will be the Consequence of it ; for if we do but consider what a deal of Phlegm one discharges in that Sickness which we call a Cold, and if it be Greenish it is almost a Purulent Matter, which comes out of the Air Vessels of the Lungs, we are presently frightened at it, and with reason, for the Disease may proceed so far that a Consumption of the Lungs will follow.

My last long Sickness was such a Cold, and it stuck so close to me, and I voided so much Green Phlegm that I was afraid I should never recover it ; but I am now so well, that in the morning when I cough, it is nothing but a clear thick Matter of the quantity of a Grey Pea ; from whence I conclude, that the Blood circulates naturally and freely thro the very smallest of the Vessels of my Lungs, and that that clear Matter is nothing but an exhalation thro the Fibres of the fine Blood-Vessels, and is the Serum of the Blood.

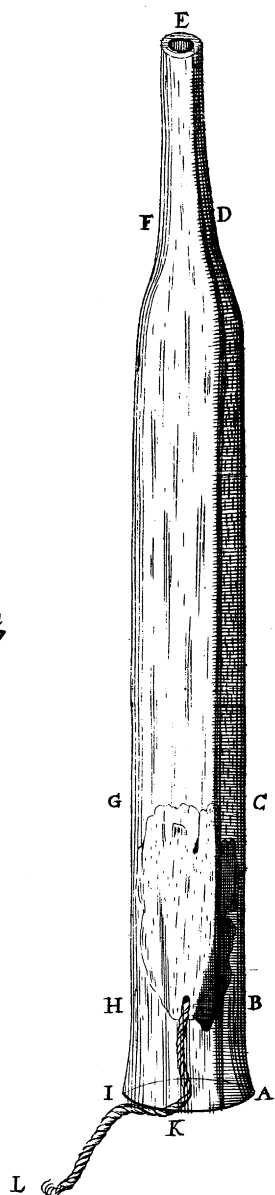
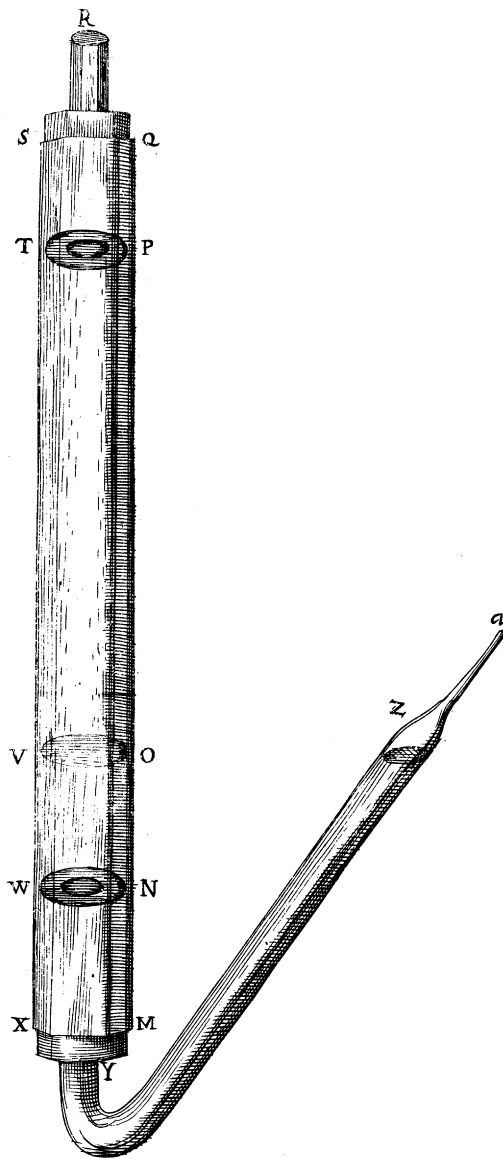
Having lately smelt some Cinnamon that was pounded in my House, I thought of what Dr *Bontekoe* says about that Spice's being a great strengthener of the Heart. I took therefore a fine piece of Cambrick, and put into it about 2 Thimbles full of strong, and well beaten Cinnamon, and tying it up, placed it in the Glass Tube, Tab. 2. Fig. 1. B C G H. Then I set my mouth in that part of the Tube, mark E, and drawing in my breath at the same place, I could plainly perceive the invisible exhaling particles of the Cinnamon to descend into my Lungs.

This Cinnamon being thus derived into the Pipes of the Lungs, we can't say that it strengthens the Heart, but rather the Lungs, unless we will affirm that the one partakes of the advantage of the other.

Tab: 2

Fig: 2.

Fig: 1.



Tab: 1.

